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(54) **Communications system with contention protocol**

(57) A communications system for data acquisition and control is provided, communicating on a time-division multiple-access communications channel, such as a radio channel. Time on the channel is divided between first periods (contention time) during which a central station 10 receives signals from remote stations 11 and second periods (polling time) when signals are transmitted to the remote units to grant access to the channel. Means are provided for transmitting a signal to the remote units to inform the remote units of a change in the length of at least the first periods of time in response to traffic measuring means.

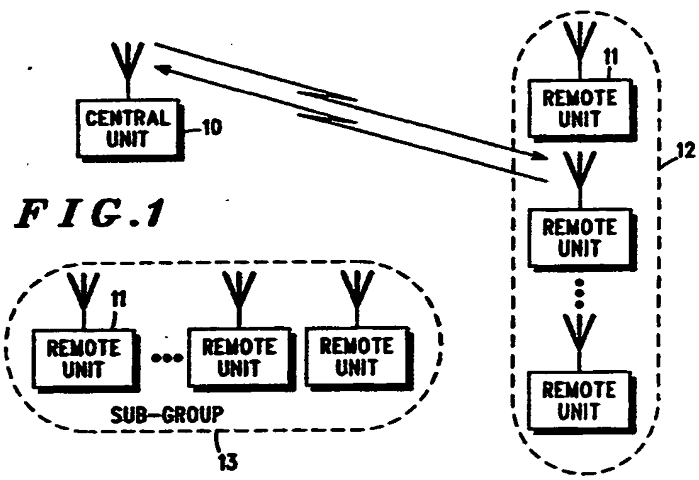
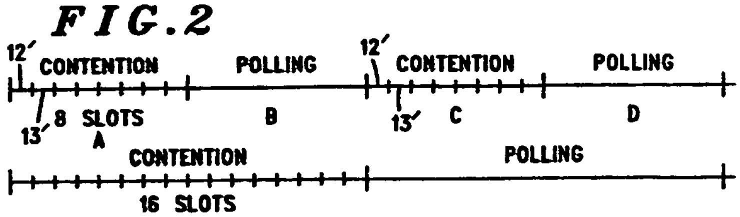


FIG.1

FIG.2



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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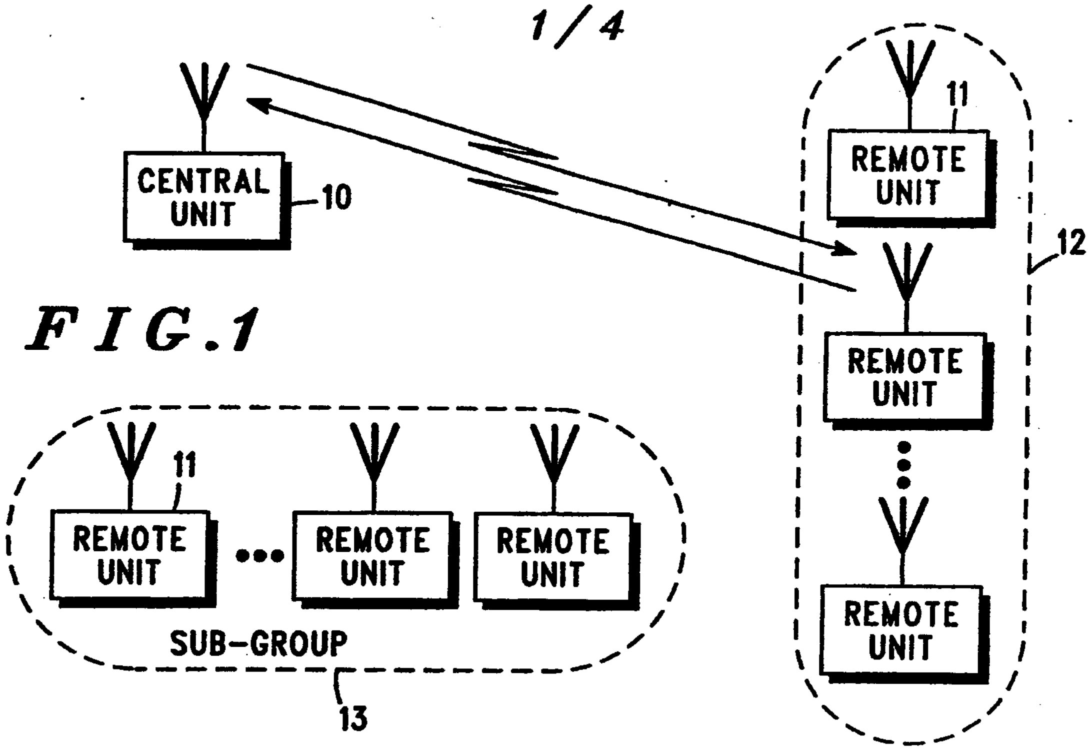


FIG.1

FIG.2

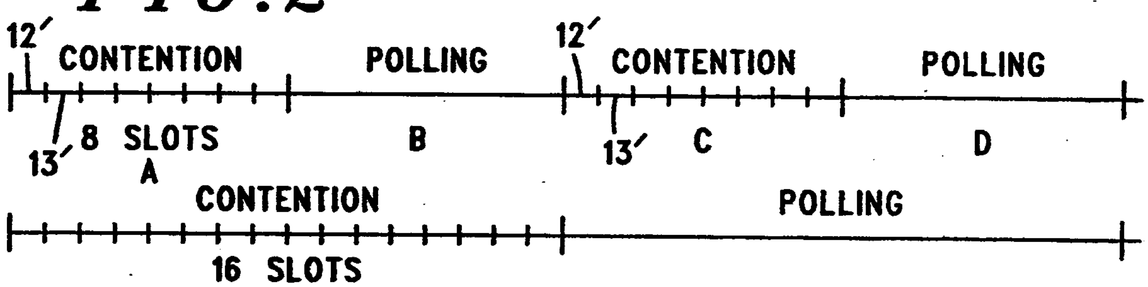
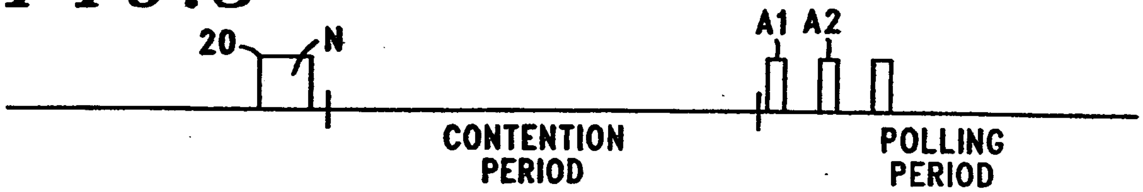


FIG.3



N	I_{NMAX}	I_{NMIN}
4	I_{4MAX}	I_{4MIN}
8	I_{8MAX}	I_{8MIN}
16	I_{16MAX}	I_{16MIN}
⋮		
512	I_{512MAX}	I_{512MIN}

FIG.5

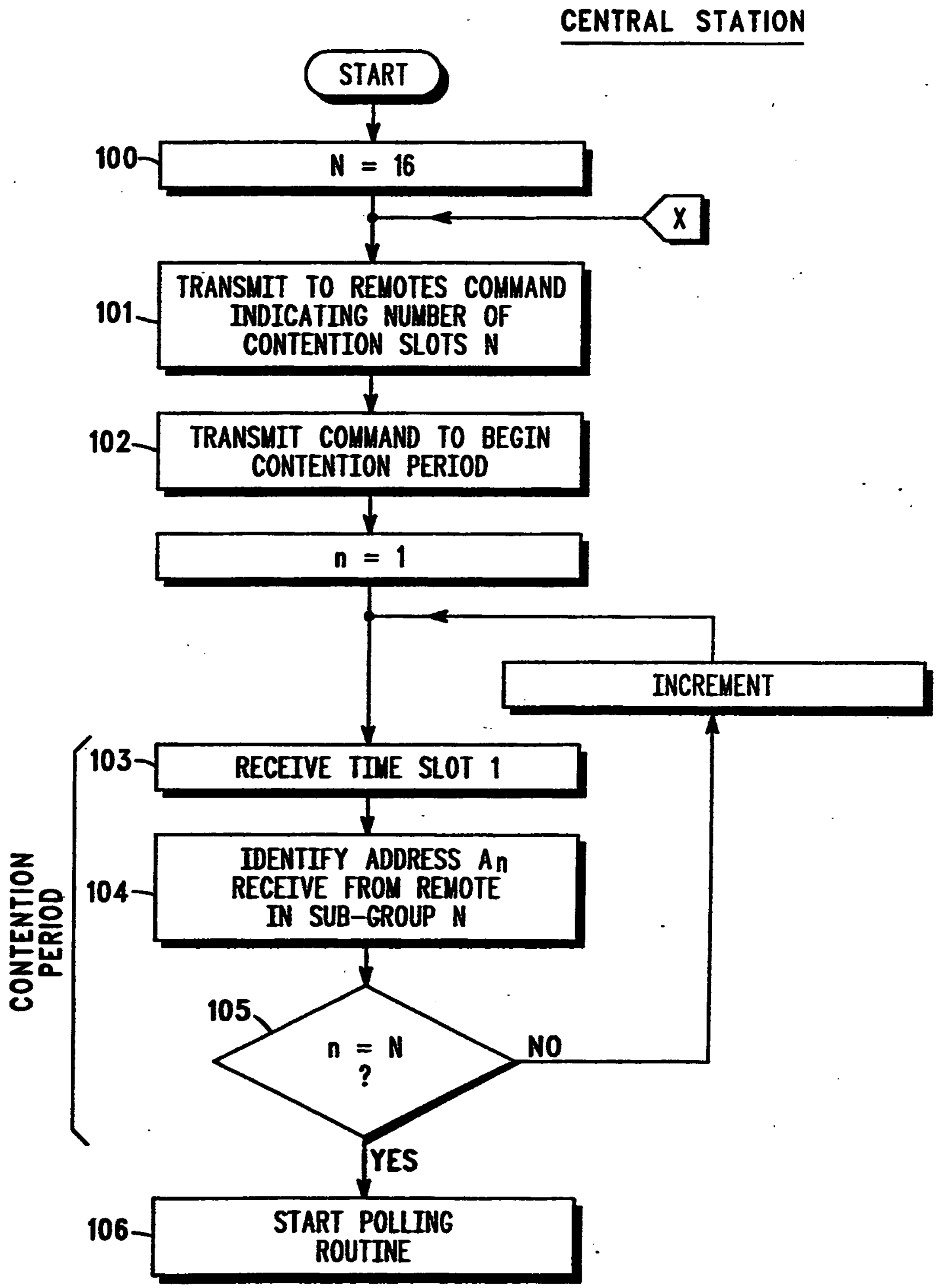

CENTRAL STATION
START
100
N = 16
X
101
TRANSMIT TO REMOTES COMMAND INDICATING NUMBER OF CONTENTION SLOTS N
102
TRANSMIT COMMAND TO BEGIN CONTENTION PERIOD
n = 1
INCREMENT
103
RECEIVE TIME SLOT 1
CONTENTION PERIOD
104
IDENTIFY ADDRESS An RECEIVE FROM REMOTE IN SUB-GROUP N
105
n = N ?
NO
YES
106
START POLLING ROUTINE

FIG. 4A

FIG.4B

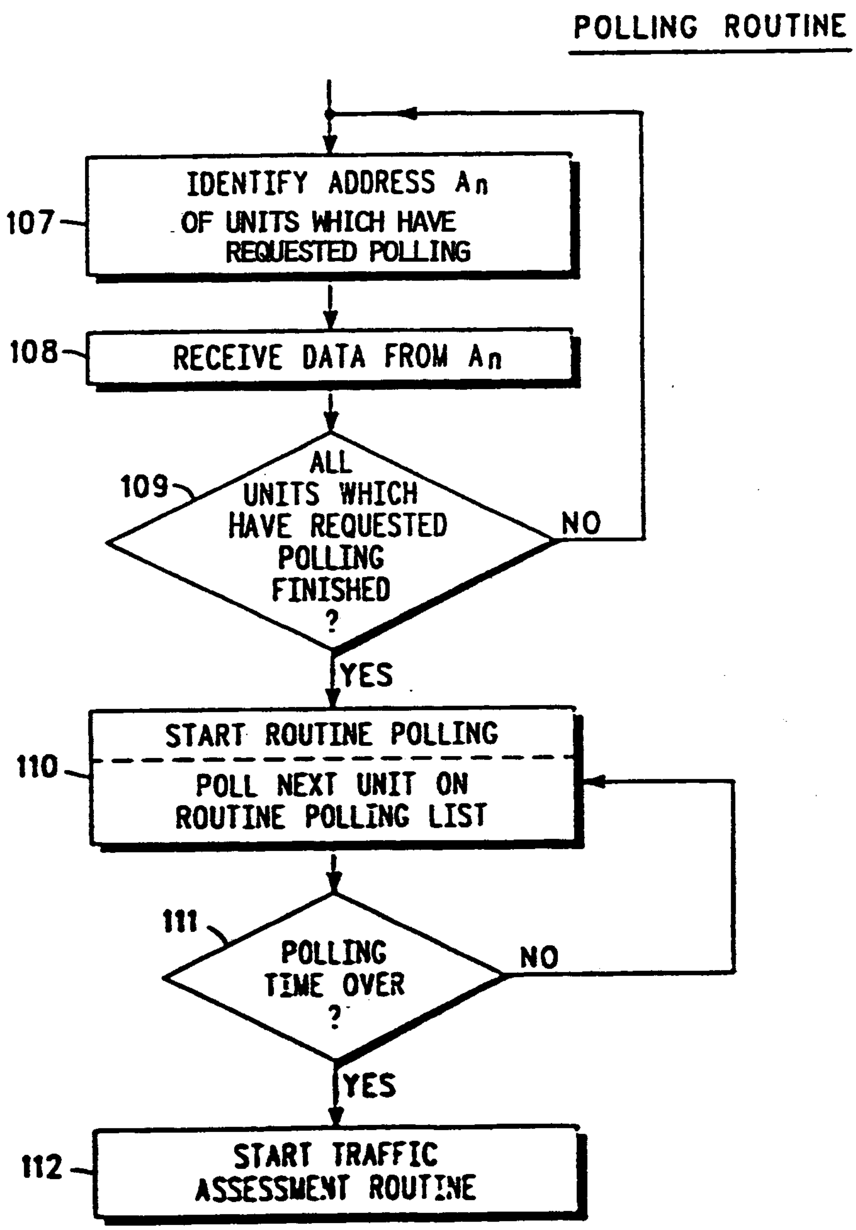
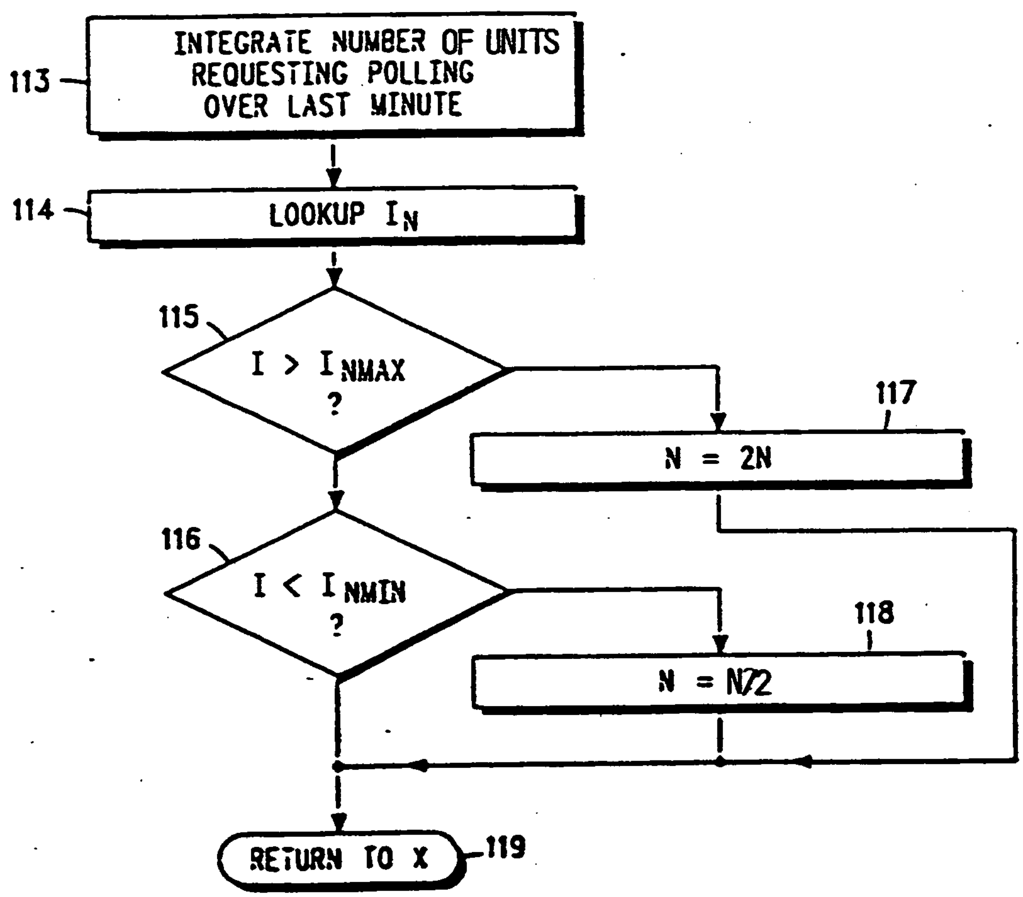

POLLING ROUTINE
107
IDENTIFY ADDRESS An OF UNITS WHICH HAVE REQUESTED POLLING
108
RECEIVE DATA FROM An
109
ALL UNITS WHICH HAVE REQUESTED POLLING FINISHED ?
NO
YES
110
START ROUTINE POLLING
POLL NEXT UNIT ON ROUTINE POLLING LIST
111
POLLING TIME OVER ?
NO
YES
112
START TRAFFIC ASSESSMENT ROUTINE

FIG.4C

TRAFFIC ASSESSMENT ROUTINE



COMMUNICATIONS SYSTEM WITH CONTENTION PROTOCOL

2236606

Background of the Invention

This invention relates to a control and data acquisition system, such as a system employing duplex radio communication between a base station and a plurality of remote stations, where the base station collects data from the various remote stations for processing and/or provides control instructions to the remote stations.

Summary of the Prior Art

Time division multiple access data communications procedures using contention schemes include 'Poll Select' (trademark) of Borroughs and 'Ethernet' (trademark). Existing systems provide means (carrier sense) in each remote unit for sensing when another remote unit is contending on the channel. The carrier which is sensed may be a carrier transmitted by the repeater, or (in a duplex system) the carrier transmitted by the central station. The carrier sensed is generally pure carrier signal with no data, i.e. a simple 'keep off channel' signal. In a duplex system, it is not possible to provide for a carrier sense. The carrier to be sensed must be transmitted from a central location and received by all potentially contending remote units. In the duplex system, however, the remote-to-central signal is not necessarily received by all the other remote units. (In contrast, where there is a repeater, the signal from a remote is repeated and may be received by all the other remote units).

In a system such as the Burroughs 'Poll Select' (trademark) system, time is divided into alternate contention periods and polling periods. During a contention period remote units which wish to send data to the central unit transmit a contention message, which is received by the central unit. At the end of the contention

period, the central unit transmits a polling command to those remote units one-by-one which have been successful in the contention procedure. The polling command includes the address of the remote unit to be polled. Upon receipt of its respective polling command, each remote unit transmits its data.

It is a problem that there may be a large number (e.g. 256) of remote units requesting contention within the contention period. The contention period can be divided into slots, each slot being of sufficient length to allow one unit to contend. If there are insufficient slots in the contention period, there will be units which are unsuccessful at contention. A unit may be unsuccessful when it transmits a request for access to the channel at the same time as another unit (being the same slot) and the signal of the other unit received at the central station is stronger. In these circumstances that other unit is successful in the contention. There may be other ways in which one unit is more successful than others. Unsuccessful units must wait until the next contention period before trying again. If there are a large number of units having to wait for such contention periods, the average response time between contention and polling is significally increased. On the other hand, if the contention period is too long, a large proportion of it remains unused and the average response time between contention and polling is unnecessarily long.

It is an object of the present invention to minimise the average response time between a request for access to the communication channel and granting of that request.

Summary of the Invention

According to the present invention, there is provided a communication system comprising a central

station and a plurality of remote units communicating on a time-division, multiple-access communications channel, wherein the central station comprises:

means for receiving signals from remote units requiring access to the channel during a first period of time,

means for transmitting signals to the remote units to grant access to the channel during a second period time following the first period;

traffic measuring means for measuring the number of remote units requiring access to the channel and means responsive to the traffic measuring means for transmitting a signal to the remote units to inform the remote units of a change in at least the first period of time.

By this means, the length of the contention period (and the number of slots therein) is variable in accordance with the traffic on the channel. The length of the polling period varies with the contention period. Thus, a short contention period can be used in times of low traffic, allowing almost all units requesting polling to transmit their requests for access and to be granted access within a short response time. In periods of heavier traffic, the contention period can be lengthened and, although the average response time will inevitably increase, the 'window' for contention is lengthened, increasing the probability that all units requesting access will be granted access during the next immediately following polling period.

It is preferred that the remote units are divided into sub-groups and only one unit in each sub-group is allowed access to the channel during the second period of time. Thus, where two units within a sub-group contend simultaneously by transmitting requests for access in the same contention time slot, only one of these will be successful, and that one will be granted access to the channel in the immediately following polling period. Means

may be provided to allow an unsuccessful unit to change the time slot in the contention period in which that unit requests access to the channel. In this sense, such a unit is temporarily assigned to a different sub-group.

Brief Description of the Drawings

Figure 1 shows an overall diagram of a system in accordance with the present invention.

Figure 2 shows two possible time divisions of a communications channel.

Figure 3 shows a signal transmitted by the central unit of Figure 1.

Figures 4a, b and c show a flow-chart describing operation of the central unit of Figure 1.

Figure 5 shows a look-up table of maximum and minimum allowable traffic levels for different contention time slot lengths.

Referring to Figure 1, there is shown a central unit 10 and a plurality (256) of remote units 11. The remote units are divided into sub-groups 12 of 16 remote units per group.

Referring to Figure 2, as an example, the time on the communication channel is divided into contention periods and polling periods which alternate. Each contention period is divided into 8 time sub-slots. Each polling period is also divided into time sub-slots. Each time sub-slot of the contention period is just sufficient to allow transmittion of a "request for access" signal from a remote unit. Each time sub-slot of the polling period is sufficient in length to allow transmittion of an instruction, including an address, from the central station 10 to the relevant remote unit 11 and for the remote unit 11 to transmit its data to the central ststion 10. The contention and polling periods are shown as approximately equal lengths, but this is by no means necessarily the

case.

Also shown in Figure 2 is the same communication channel divided into contention periods of 16 sub-slots. The figure shows different divisions of the same channels. The other channel of the duplex communication is not shown. During the contention period, the central unit is free to transmit other data or instructions, while receiving the access request from the remote. During the polling period, there is two-way communication.

In accordance with the present invention the central unit 10 can control the division of the communication channels according to the alternatives of Figure 2, and other alternatives.

In the time divisions shown in the upper part of the figure, the units in sub-group 12 may be allocated sub-slot 12, and the units in sub-group 13 may be allocated sub slot 13 etc. If two units in sub-group 12 contend simultaneously in sub-slot 12, one will be unsuccessful. This unit can try again in sub-slot 12 - though preferably it switches to a different sub-slot and transmits in sub-slot 13. Clearly, in the case of this unit, it will not gain access to the channel until at least time slot D. Its response time has at least doubled. If there are many such units, the average response time rapidly increases. In such a case, the central unit 10 doubles the length of the contention period, and the corresponding period as shown in the lower half of the figure.

Referring to Figure 3, there is shown the signal transmitted by the central unit 10 to the remote units. Immediately prior to the commencement of the contention period, the central unit 10 transmits a command 20, which contains a number (N) defining the number of sub slots in the immediately following contention period. Included in the command 20 is a command to commence the contention period. During the subsequent polling period, the central unit transmits the addresses A1, A2 etc. of the remote

units which have been successful during the contention period.

Referring to Figure 4a the operation of the central unit 10 is shown. When the system starts up, the number N is set at a default number, e.g. 16. The central station transmits the command 20 (steps 101 and 102) indicating to the remote units the number of contention slots N and indicating the start of the contention period. When the contention period starts, the central station receives the first time slot (n=1) if a remote unit in sub-group 11 has transmitted its address A_n, this address is identified and stored. This receive process is repeated N times, after which time (step 105) the polling routine is commenced (step 106).

The polling routine is described in Figure 4b. The central unit transmits signals which include the addresses A_n of those units which were identified in step 104. After the transmission of each address, the data from the identified unit is received in step 108. This transmit - receive sequence is repeated for each of the units which requested polling. If there is still time during the polling period, the central unit can undergo a routine polling sequence, in which the next unit on a routine polling list is polled (Step 110) in the same manner as steps 107 and 108. This is a routine, unsolicited polling. When the polling time is over, a traffic assessment routine is commenced.

In the traffic assessment (Figure 4c), the total number of units which have requested polling over the last minute is integrated. A look-up operation is carried out in the look-up table of Figure 5. The measured integral (I) is compared with the maximum and minimum levels for that integral. If the traffic level as represented by integral I exceeds a maximum, N is doubled in step 117, giving a contention time period of twice the previous length. If the traffic level as represented by integral I

is less than a predetermined minimum, as determined by the look-up table, the number N of sub slots in the contention period is halved (step 118). At the end of the traffic assessment routine, the base station returns to point X at the start of its program and repeats step 101 to begin the next contention period.

The invention may be used, for example, for assistance for controlling of gaming machines, in which the time for response needs to be kept low. For example, if a customer requests a game by inserting a coin a slot, the customer expects a response within a matter of seconds. It would be inadequate for the gaming machine to fail to response for a period of, for example a minute, due to the gaming machine waiting for a response from its central control station. In such a system, a prior art carrier sense arrangement may not meet all the system requirements, whereas a full duplex system allows the central station to transmit to any unit at any time, e.g. informing one or more units that a jackpot has been won.

The integration time in step 103 may be variable according to the derivative of the traffic (i.e. the rate of change of the traffic). Similarly, the factors used in step 117 and 118 may be variable.

As the contention time period is opened, so the sub-groups are sub-divided to provided more sub-groups and vice-versa.

The present invention relates to a communication system, and independently relates to central and remote units and a method of control thereof.

It will, of course, be understood that the above description has been given by way of example only, and that modification of detail may be made within the scope of the invention.

CLAIMS

1 A communications system comprising a central station and a plurality of remote units communicating on a time-division multiple-access communication channel, wherein the central station comprises:

means for receiving signals from remote units requiring access to the channel, during a first period of time,

means for transmitting signals to the remote units to grant access to the channel during a second period of time following the first period;

traffic measuring means for measuring the number of remote units requiring access to the channel and

means responsive to the traffic measuring means for transmitting a signal to the remote units to inform the remote units of a change in the length of at least the first period of time.

2 A communications system according to claim 1 wherein the remote units are divided into a plurality of sub-groups, each sub-group comprising a plurality of units and wherein means for receiving signals from the remote units provides for receipt of one signal from a remote unit in each sub-group during each first period of time, such that only that unit in each sub-group is granted access to the channel in the second period of time.

3 A system according to either of claims 1 and 2 wherein each remote unit is assigned a time slot during the first period when that unit is allowed to transmit its signal to the control unit indicating a request for access to the channel and wherein each remote unit comprises means for timing transmission of its request from the start of the second period so as to transmit during its assigned time slot.

4 A remote communications unit for communication on a system according to any one of claims 1 to 3 comprising means for timing transmission of a signal indicating a request for access to the channel,

means for receiving a traffic-dependent signal from a central station, and means for determining the total amount of time available for transmission of the signal indicating a request for access and means for controlling the transmission timing means in response to said means for determining.

5 A remote communications unit for communication on a system according to claim 3 comprising means for determining when a signal indicating a request for access has been transmitted but a signal granting access has not been received and means for adjusting timing of its transmission so as to transmit its signal to the central unit in a different time slot during a subsequent first period of time.

6 A central communications station for communication with a plurality of remote units on a time-division multiple-access communication channel, said central station comprising:

means for receiving signals from remote units requiring access to the channel, during a first period of time,

means for transmitting signals to the remote units to grant access to the channel during a second period of time following the first period;

traffic measuring means for measuring the number of remote units requiring access to the channel and

means responsive to the traffic measuring means for transmitting a signal to the remote units to inform the remote units of a change in the length of at least the first period of time.

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